

WHAT IS CLAIMED IS:

1. A method for transforming and communicating an arbitrary bit-stream data into a bit-stream suitable for input to a dense wavelength division multiplexing (DWDM) network, the method comprising the steps of:
 - receiving an optically encoded digital data stream;
 - converting the encoded digital data stream to a binary data stream;
 - applying error correction to the binary data stream to generate an error correcting code over a fixed number of input bits to correct for error multiplication;
 - placing the error correcting code into the binary data stream to produce a bit-serial data stream;
 - applying a self-synchronous scrambler on the bit-serial data stream, the scrambler having an executable logic to equalize “1”s and “0”s, in the arbitrary bit-stream data, over a plurality of bit-clock periods to produce scrambled bit-stream data;
 - encoding the scrambled bit-stream data; and
 - transmitting the encoded scrambled bit-stream data independent of its bit-stream characteristics and line coding.
2. The method as in claim 1, further comprising:
 - receiving and demultiplexing the encoded scrambled bit stream data;
 - converting the encoded scrambled bit stream data into a binary data stream;
 - descrambling the binary data stream using a self-synchronous descrambler having an executable logic, that is opposite to logic executed by the self-synchronous scrambler, to produce a bit-serial data stream;
 - identifying frame synchronization by applying the error correcting code on the bit-serial data stream;
 - separating data bits from error correcting code bits;

applying the error correcting code to correct single bit errors; and
encoding descrambled binary bit stream in a format compatible with the
encoded input data stream.

3. The method as in claim 2, further comprising:

providing a feedback loop to the self-synchronous descrambler to
improve error correction performance by providing information of an error-bit;
retaining a scrambled copy of the error-bit; and
substituting the error-bit by its ones complement.

4. The method as in claim 1, wherein the logic executed by the self-
synchronous scrambler is of the form

$$y_k = x_k \oplus (\sum_{p=1}^m (y_{(k-p)} \oplus S_p))$$

where

\oplus denotes Exclusive OR function;

x_k = kth bit input to the scrambler;

y_k = kth bit output from the scrambler;

m = number of stages of the scrambler; and

S_p = 1 if Stage p is active and 0 if p is not active.

5. The method as in claim 2, wherein the logic executed by the self-
synchronous descrambler is of the form:

$$x_k = y_k \oplus (\sum_{p=1}^m (y_{(k-p)} \oplus S_p))$$

where

\oplus denotes Exclusive OR function;

$y_k = k^{\text{th}}$ bit input to the descrambler;

$x_k = k^{\text{th}}$ bit output from the descrambler;

m = number of stages of the descrambler; and

$S_p = 1$ if Stage p is active and 0 if p is not active.

6. The method as in claim 1, wherein optical encoding is performed using NRZ or RZ encoding techniques.

7. The method as in claim 1, wherein said method eliminates bit-pattern artifacts in communication networks employing optical encoding schemes which fail to provide a DC balance.

8. In a digital data communications system having a transmitting station, a receiving station, and a communication medium communicatively coupling the transmitting and receiving stations, a method for transforming an arbitrary bit-stream data from the transmitting station to a bit-stream suitable for input to the data communications system, the method comprising:

receiving an optically encoded digital data stream by a DWDM input terminal unit;

generating a bit-serial data stream from optically encoded digital data received from the transmitting station;

applying a self-synchronous scrambler on the bit-serial data stream having an executable logic to equalize “1”s and “0”s in an input bit-pattern

over time periods of several bit-clock periods and producing scrambled bit-stream data; and

encoding and transmitting the scrambled bit-stream data independent of its bit-stream characteristics and line coding.

9. The method as in claim 8, wherein the step of generating the bit-serial data stream comprises:

converting the encoded digital data stream to a binary data stream;

applying error correction to the binary data stream to generate an error correcting code over a fixed number of input bits to correct for error multiplication; and

placing the error correcting code into the binary data stream to produce a bit-serial data stream.

10. A method for transforming an arbitrary bit-stream into a bit-stream suitable for transmission on a digital data communications network and reconstituting the arbitrary bit-stream from transformed bit-stream, the method comprising:

converting an input data stream into a binary data stream;

generating an error correcting code over a fixed number of input bits to correct for error multiplication;

placing the error correcting code into the binary data stream to produce a bit-serial data stream;

applying a self-synchronous scrambler on the bit-serial data stream, the scrambler having an executable logic to equalize “1”s and “0”s in an input bit-pattern over a plurality of bit-clock periods to produce a scrambled bit-stream; and

encoding and transmitting the scrambled bit-stream data independent of its bit-stream characteristics and line coding.

11. The method as in claim 10, further comprising:

receiving and converting the encoded bit-stream data into a binary data stream; and

descrambling the binary data stream using a self-synchronous descrambler executing a logic that is opposite to logic of the scrambler.

12. The method as in claim 10, wherein the logic executed by the scrambler is of the form:

$$y_k = x_k \oplus (\sum_{p=1}^m (y_{(k-p)} \oplus S_p))$$

where

\oplus denotes Exclusive OR function;

x_k = kth bit input to the scrambler;

y_k = kth bit output from the scrambler;

m = number of stages of the scrambler; and

S_p = 1 if Stage p is active and 0 if p is not active.

13. The method as in claim 11, wherein the logic executed by the descrambler is of the form:

$$x_k = y_k \oplus (\sum_{p=1}^m (y_{(k-p)} \oplus S_p))$$

where

\oplus denotes Exclusive OR function;

y_k = kth bit input to the descrambler;

$x_k = k^{\text{th}}$ bit output from the descrambler;

$m = \text{number of stages of the descrambler; and}$

$S_p = 1 \text{ if Stage } p \text{ is active and } 0 \text{ if } p \text{ is not active.}$

14. A digital data communications system for transmitting an arbitrary input bit-stream data from a source station to a destination station via an optical communications medium communicatively coupling said source and destination stations, the digital data communications system comprising:

a DWDM input unit receiving the arbitrary data stream from the source station, said DWDM input unit including

an optical-to-electrical conversion unit for converting the arbitrary input bit-stream data into binary data stream;

a self-synchronous scrambler executing a logic to equalize the number of “1”s and “0”s, in the binary data stream, over a plurality of bit-clock periods to produce a scrambled data stream; and

an electrical-to-optical conversion unit for encoding and transmitting the scrambled data stream via the optical communication medium, wherein said scrambler enables said DWDM input unit to transport the arbitrary input bit-stream data independent of its bit-stream characteristics and line coding; and

a DWDM output unit for receiving the scrambled data stream transmitted via said optical communications medium, said DWDM output unit including a self-synchronous descrambler executing a logic that is opposite to the logic executed by said self-synchronous scrambler.

15. The system as in claim 14, further comprises:

a multiplexer for placing more than one channel of data on the optical communications medium.

16. The system as in claim 14, wherein the logic executed by the scrambler is of the form:

$$y_k = x_k \oplus (\sum_{p=1}^m (y_{(k-p)} \oplus S_p))$$

where

\oplus denotes Exclusive OR function;

x_k = k^{th} bit input to the scrambler;

y_k = k^{th} bit output from the scrambler;

m = number of stages of the scrambler; and

S_p = 1 if Stage p is active and 0 if p is not active.

17. The system as in claim 14, wherein the logic executed by the descrambler is of the form:

$$x_k = y_k \oplus (\sum_{p=1}^m (y_{(k-p)} \oplus S_p))$$

where

\oplus denotes Exclusive OR function;

y_k = k^{th} bit input to the descrambler;

x_k = k^{th} bit output from the descrambler;

m = number of stages of the descrambler; and

$S_p = 1$ if Stage p is active and 0 if p is not active.

18. The system as in claim 14, wherein the logic executed by the scrambler is of the form:

$$y(k) = x(k) \oplus y(k-m)$$

where

$x(k)$ is the input to the scrambler;

$y(k-m)$ is buffered output from m bits prior; and

$y(k)$ is the line output.

19. The system as in claim 14, wherein the logic executed by the descrambler is of the form

$$x(k) = y(k) \oplus y(k-m); \text{ where}$$

$x(k)$ is the input to the scrambler;

$y(k-m)$ is buffered output from m bits prior;

$y(k)$ is the line output.

20. A method for transforming an arbitrary bit-stream into a bit-stream suitable for input to a dense wavelength division multiplexing (DWDM) network, the method comprising:

- receiving an optically encoded digital data stream by an optical input;
- converting the encoded digital data stream to a binary data stream;
- adding fixed-length overhead fields to the binary data stream to produce a bit-serial data stream;
- applying a self-synchronous scrambler on the bit-serial data stream, the scrambler executing a logic to equalize “1”s and “0”s in an input bit-pattern over a plurality of bit-clock periods to produce scrambled bit-stream data;
- generating and applying error correction code (ECC) to the scrambled bit-stream data to correct single bit-errors;
- placing the scrambled bit-stream data and error correction code into a variable length frame having frame synchronization bytes to produce a scrambled bit-stream data with ECC; and
- encoding and transmitting the scrambled bit-stream data with ECC using optical encoding on a carrier suitable for optical multiplexing, wherein the scrambled bit-stream data with ECC is transmitted independent of its bit-stream characteristics and line coding.

21. The method as in claim 20, further comprising:

- receiving and demultiplexing the encoded bit stream from the carrier;
- identifying frame synchronization by applying the error correcting code on the bit-stream data;
- applying the error correcting code to correct single bit errors;
- extracting the scrambled bit stream from the variable length frame and applying error correction from the error correcting code employed;

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descrambling the bit-stream data using a self-synchronous descrambler executing a logic that is opposite to logic executed by the scrambler; separating data bits from error correcting code bits; and encoding descrambled binary bit stream in a format compatible with the encoded input data stream.

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